International Conference on Applied Energy 2019
Aug12-15, 2019, Västerås, Sweden
Paper ID: 0928

HYDROGEN FROM SOLAR ENERGY IN CITY OF GHARDAIA THROUGH STEAM METHANE (CH4) REFORMING USING TRACKING SYSTEM

Chawki Ameur Menad*[1], Rabah Gomri[1].

[1] University Frères Mentouri Constantine, Faculty of Sciences and Technology, Department of Génie Climatique, Constatine, Algeria

ABSTRACT

Algeria holds one of the best solar energy resources in the world, where the most and the dominant part is located in the south of the country. Ghardaia is one of the best cities for this renewable energy resource, and it is suitable for producing other energy sources such as hydrogen through the solar parabolic concentrator. The natural gas is available in all parts of the country. However, it affects the environment. This paper is focusing on producing hydrogen from Steam Methane reforming in the city of Ghardaia through parabolic concentrator using the tracking system. Selecting CH_4 as a source of hydrogen production is to minimize CO_2 emission in the environment. The obtained results proofed that the amount of hydrogen produced is 0,9KgH_2/m^2/Day.

Keywords: Hydrogen Production; CSP System; Tracking System; CH_4; Steam Methane Reforming; Solar Energy.

1. INTRODUCTION

Tracking solar system is the best solution for absorbing the highest solar irradiation in different location and positions. Many research project about exploiting renewable energy have been developed in the last few years, one of this research papers was developed by Malvi et al [1] for creating a hybrid solar panels by a combination between solar thermal energy and photovoltaic energy and phase change material system. Agrafiotis et al [2] have been proposed the exploitation of solar energy for the dissociation of water and production of hydrogen via an integrated thermo-chemical reactor/receiver system. Jeremiah et al [3] have mentioned on their research the objective of generating hydrogen by solar photovoltaic (PV) array and then collected for data analysis to demonstrate the efficiency of the hydrogen production in all the steps of the experiment. Their positive results proofed that the studied case model allows demonstrating at least one-hour operation per hydrogen charging at room temperature. Quaschning and Trieb [4] developed a research about the choice of exploiting solar power for creating new opportunities for hydrogen production; the final cost estimation for hydrogen and solar electricity generation showed the potential of both technologies for a sustainable energy industry. In terms of using renewable energy resources for hydrogen production, some researchers were focusing just on the production of hydrogen by electrolysis powered from wind and solar resources. As a result, they got a reasonable price for producing hydrogen from wind and solar energy [5]. Ayati et al [6] proposed producing electricity by the photovoltaic panel for electrolysis of water. Swofford and Slattery [7] studied the production of electricity by using wind energy in Texas (USA) for understanding the relationship between production of wind energy and the public. Moreover, Ozgener et al [8] studied the exergoeconomic for evaluating the performance of geothermal heat pumps. Another kind of renewable energy (geothermal energy) was discussed by Stuart J. Self et al [9] to minimize consumption of energy, cost, and emission of CO2 during generation of heat pumps. Mahmoudi et al [10] studied the desalination of seawater by the application of geothermal energy in Algeria because there are many available resources. Sesto and Casale [11] studied the application of wind energy for production of the electricity. Another research has been developed by Salmon et al [12] introducing two models between wind speed, direction, and energy estimates. Using solar energy for producing hydrogen in the city of Ghardaia through methane reforming using tracking system is the main goal of this paper.

2. SOLAR ENERGY IN ALGERIA

Solar potential energy in Algeria is the dominant renewable energy resource in the south of the country, and many research projects have been developed for measuring the location and suitable technology for its applications. In this paper, collecting data has been developed in the city of Ghardaia which is one of the best cities. Figures 1 and 2 represent the potential of irradiation and temperature during the measurement period.

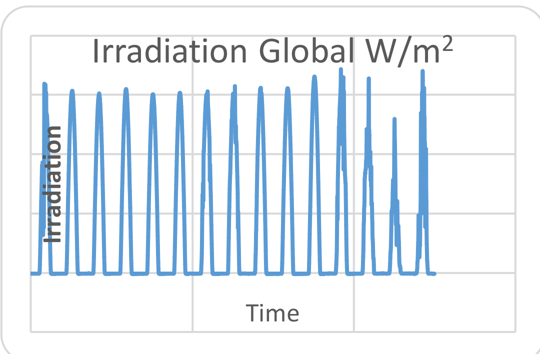

Fig 1 Solar irradiation in the city of Ghardaia

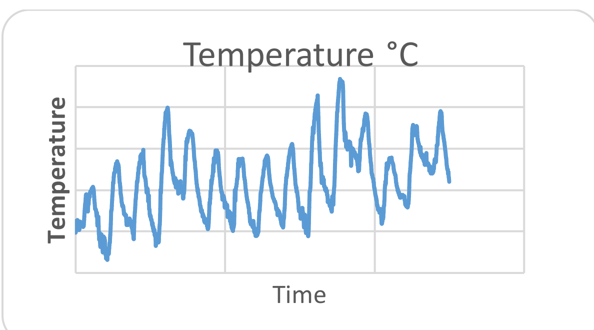

Fig 2 Variation of the temperature in the city of Ghardaia

Figure 3 shows the solar irradiation in Algeria which is mainly located in the south of the country [13] for understanding the solar energy map in Algeria

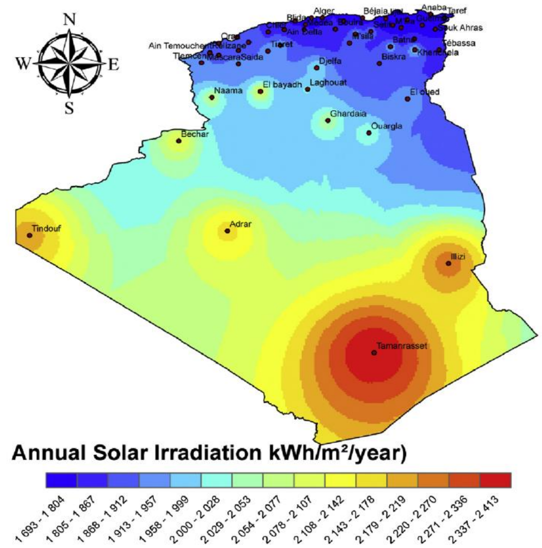

Fig 3 Annual Average of the global horizontal solar irradiation in Algeria

3. HYDROGEN FROM SOLAR ENERGY IN ALGERIA

Using the thermo-chemical cycles technology under Algerian climate is a suitable pathway for hydrogen production due to the presence of natural gas and solar energy resource. Connecting the existing natural gas station to solar energy power station is an efficient solution for the future energy plan consumption. Saving the environment from CO_2 emission, through extracting the hydrogen from CH_4, will decrease the greenhouse effect by 50%. The proposed tracking system in this paper has taken on consideration production of hydrogen from solar energy through system methane reforming. An interesting research paper was published [14] for an understanding of the impact of solar concentrators on the future of hydrogen production under Algerian climate. Figure 4 shows the Contribution of renewable energy by type from 2011 to 2030 where CSP technology is dominant.

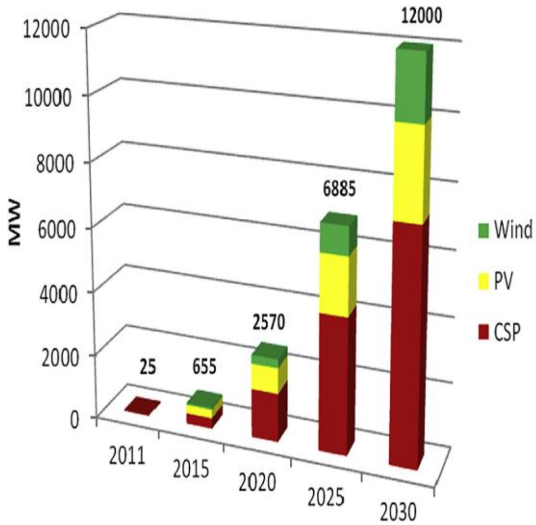

Fig 4: Contribution of renewable energy by type from 2011 to 2030

3.1 Comparing between solar energy systems for hydrogen production.

The following table shows the existing solar systems for hydrogen production under Algerian climate which are based on experimental studies

Tab 1 Comparing between different solar systems for hydrogen production under Algerian climate

Type of system	Description of the solar system	Temperature °C	Energy efficiency %
Photovoltaic	Monocrystalline Multycristaline Thin films solar panel	0-55°C	12-25%
Thermal solar system (high temperature)	Solar Parabolic Trough collector system [15].	> 826.85°C	42.21%
Thermal solar system (medium temperature)	Power tower [16].	515ºC	86.55%

3.2 Hydrogen production from solar energy in the city of Ghardaia in Algeria

The suitable technology for producing hydrogen in the city of Ghardaia is CSP using a tracking system through steam methane CH_4 reforming. Figure 5 explains the process of hydrogen production by using the tracking systems in the CSP system.

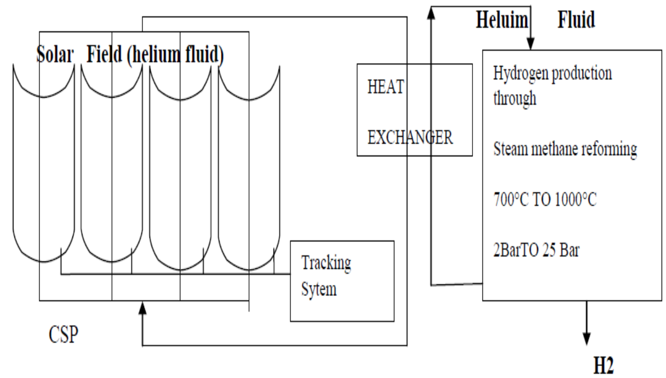

Fig 5 Hydrogen From Solar Energy in City of Ghardaia through Methane (CH4) Reforming using tracking system.

There are three dominant parts of the proposal model:

- Solar field: in this the part CSP system has been used for absorbing the solar irradiation in the city of Ghardaia and increasing the temperature of the helium to 1100°C for hydrogen production process in the last part.
- Heat exchanger and tracking system for controlling the helium temperature in the second part catching the solar irradiation respectively.
- The hydrogen station where the hydrogen production through steam methane reforming cycle in high temperature (700°C to 1000°C).

4. RESULTS AND DISCUSSIONS

Collecting data from a solar station in the city of Ghardaia has been done between 01/01/2017 to 15/01/2017 for analytical calculation.
The amount of hydrogen in the studied period was very efficient. Figure 6 shows that the highest value was 0. 9 $KgH2/m^2/day$, and the CSP with tracking system has transformed all the solar irradiation to Hydrogen production without load. The thermal solar energy is efficient in Algeria climate for hydrogen production.

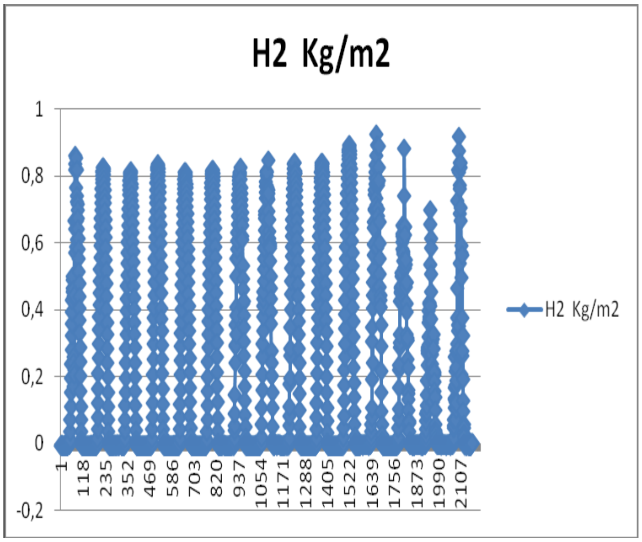

Fig 6 Hydrogen produced from Steam methane reforming through CSP technology with tracking system.

Figure 7 shows the power of the tracking system in the CSP system. The obtained results show that the CSP efficient is 80% which is very efficient for hydrogen production in the long period under Algerian climate in the city of Ghardaia.

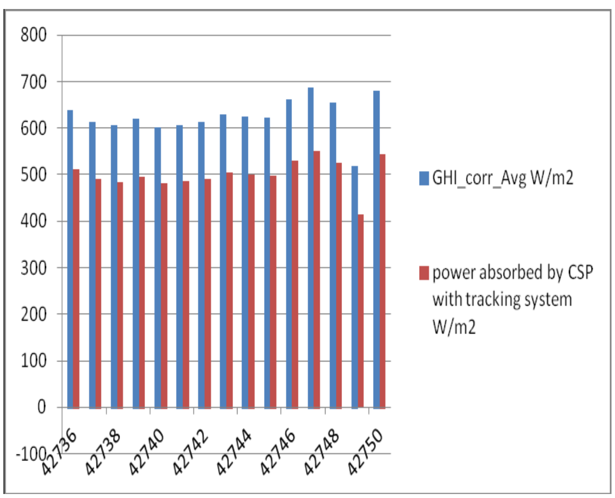

Fig 7 Power absorbed by CSP with tracking system.

The Figure 8 describes the variation of the temperature on the hydrogen production through the proposed model in the city of Ghardaia. The obtained results show the power of tracking system even in low temperature, where the hydrogen production is high 0,9KgH_2/m^2/day.

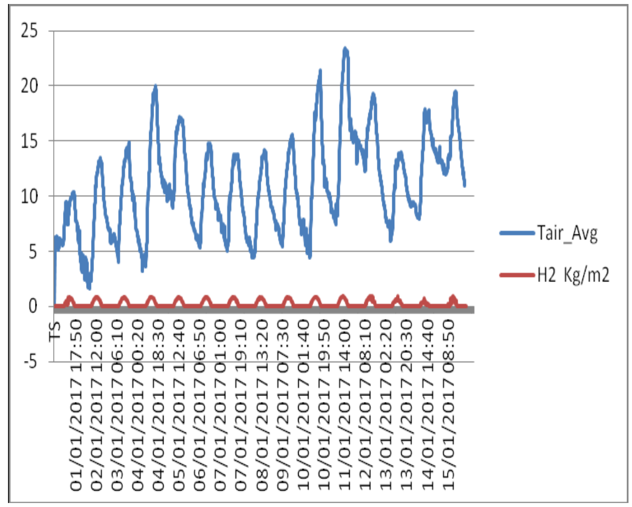

Fig 8 Varaition of Hydrogen production on the temperature in city of Ghardaia.

5. CONCLUSIONS

The purpose of this research paper is to show the power of CSP solar system in the city of Ghardaia for producing hydrogen through steam methane reforming with a tracking system. The obtained results proofed that the selected model (CSP with tracking system) under Algerian climate in the city of Ghardaia is efficient due to the amount of hydrogen produced per meter square.

ACKNOWLEDGEMENT

The principal author acknowledges his parents for all efforts, which they have given him. The principal author would like to acknowledge Mr. M. Jenckenson for all his efforts and help with preparing this paper.

REFERENCE

[1] Malvi CS, Dixon-Hardy DW, Crook R. Energy balance model of a combined photovoltaic solar-thermal system incorporating phase change material. Solar Energy 2011; 85(7):1440–1446.

[2] Agrafiotis C, Roeb M, Konstandopoulos AG, Nalbandian L, Zaspalis VT, Sattler C, Stobbe P, Steele AM. Solar water splitting for hydrogen production with monolithic reactors. Solar Energy 2005; 79:409–421.

[3] Jeremiah F, Wilson, Sesha S, Srinivasan, Bria M, Moore, Henderson L, Ely S, Sharma PC. Hydrogen production using solar energy. A Journal of Undergraduate Research in Physics 2013.

[4] Quaschning V, Trieb F. have developed. Solar Thermal Power Plants for Hydrogen Production.

HYPOTHESIS IV Symposium, Stralsund, Germany, 9-14 September 2001;198-202.
[5] Rahil A Gammon R. Dispatchable Hydrogen Production at the Forecourt for Electricity Demand Shaping. Sustainability 2017; 9(10):1785.
[6] Ayati F, M'Raoui A, Belhamel M, Rebai A. Modélisation d'un Système de Production d'Hydrogène Solaire par Electrolyse. Revue des Energies Renouvelables 2004; 7 :135-150.
[7 Swofford J, Slattery M. Public attitudes of wind energy in Texas: Local communities in close proximity to wind farms and their effect on decision-making. Energy Policy 2010; 38(5) : 2508–2519.
[8] Ozgener O, Hepbasli A, Ozgener L. A parametric study on the exergoeconomic assessment of a vertical ground-coupled (geothermal) heat pump system Building and Environment 2007; 42:1503–1509.
[9] Stuart J. Self, Bale V. Reddy, Marc A. 284 Rosen, Geothermal heat pump systems: Status review and comparison with other heating options. Applied Energy, 2013; 101:341-348
[10] Mahmoudi H. Assessment of wind energy to power solar brackish water greenhouse desalination units: A case study from Algeria. Renewable and Sustainable Energy Reviews 2009; 13(8):2149–2155.
[11] Sesto E, Casale C. Exploitation of wind as an energy source to meet the world's electricity demand. Journal of Wind Engineering and Industrial Aerodynamics 1998; 74–76:375–387.
[12] Salmon JR, Walmsley JL. A two-site correlation model for wind speed, direction, and energy estimates. Journal of Wind Engineering and Industrial Aerodynamics 199; 79:233–268.
[13] Rahmouni S, Negrou B, Settou N, Dominguez J, Gouareh A. Prospects of hydrogen production potential from renewable resources in Algeria, International Journal of Hydrogen Energy 2017; 42: 1383–1395.
[14] Gouareh A, Settou N, Khalfi A, Recioui B, Negrou B, Rahmouni S, Dokkar B. GIS-based analysis of hydrogen production from geothermal electricity using CO2 as working fluid in International Journal of Hydrogen Energy 2015; 40 (44), 15244-15253.
[15] Bellos E Tzivanidis C, Antonopoulos KA. A detailed working fluid investigation for solar parabolic trough collectors. Applied Thermal Engineering 2017; 114:374–386.
[16]Y. Luo X, Du D. Wen. The novel design of central dual-receiver for the solar power tower. Applied Thermal Engineering, 2015;91:1071-1081.

